

Integration of Airborne Aerosol Prediction Systems and Vegetation Phenology to Track Pollen for Asthma Alerts in Public Health Decision Support Systems

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Theresa Crimmins & Jake Weltzin USGS National Phenology Network

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NASA Public Health Review September 2013

Transitions

Science Update

1. Pollen Sampling
2. Pollen Source Concentration Masks (ground based)
3. PREAM
4. MODIS generated pollen source maps

Public Health

1. EDAC
2. SYRIS
3. New Mexico EPHT

Outreach Activities

1. National Phenology Network
2. NSF funded SciGirl

Presentations/Publications

Housekeeping- Schedule, Budget, Problems

FY14 Plans



Transitions

Anup Prasad Chapman University - back to India

Alfredo Huente permanently at University of Technology Sydney

Al Zelicoff to St. Louis University

Margaret Menache replaced by Barbara Toth replaced by Kenneth Geter

Ana Vukovic & Mirjam Vujadinovic Faculty of Agriculture, University of Belgrade, Serbia

Nickovic Slobodan from Geneva to Belgrade, Serbia

Landon Bunderson –finished PhD. Post-Doc Iowa.

On going health issues with team members

Univ of AZ computer move- 3 months down time/University of Belgrade CPU crash lost PREAM runs



POLIEN





Climate Effects and Aeroallergens

- **Effects of Climate Change**
 - Plant Distribution Changes
 - Plant Phenology Changes
 - Plant Growth and Productivity Increases
 - Pollen Increase
 - Increases in Allergen Level
- **Climate Variability**
 - Climate variability and extreme weather events can also affect airborne pollen and spores levels

Influence of preseason meteorological variables

- ▶ Start date
 - ▶ Significantly correlated with mean monthly temperature in December ($r = 0.467, p = 0.038$) and November rainfall ($r = 0.468, p = 0.038$)
- ▶ Cumulative Season Total (CST)
 - ▶ Significantly correlated with mean maximum temperature in December ($r = 0.4740, p = 0.035$)



Correlation of average daily *Juniperus* pollen concentration with meteorological variables from 1987 to 2006

Meteorological Variable	Main season r
Max daily temperature	0.607***
Min daily temperature	0.371***
Mean daily temperature	0.546***
Rainfall	-0.143***
Rainfall (1 day lag)	-0.164***
Rainfall (2 day lag)	-0.069
RH	-0.282***
Mean wind speed	0.117**
Sunshine	0.257***



* p <0.05

** p<0.01

*** p<0.001



Seed Cones and Pollen Cones of *Juniperus pinchotii* (Red Berry Juniper)

Fall Pollinating Juniper – mid September to late November



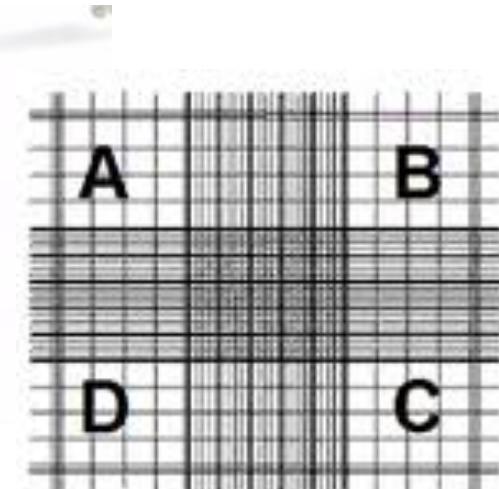
Pollen Forecasting

- Simplest models based on previous years' pollen data
- Phenology models based on flower development
 - Start-date forecasts for spring pollen based on winter weather
 - Growing degree days calculated from past data
 - Remote sensing to determine “greening”
- Day to day forecasting models use meteorological conditions and phenology
 - Statistical models to identify meteorological factors
 - May incorporate dispersion models to show where pollen is going to travel
- Yearly severity based on preseason meteorological data – often previous summer



Pollen Production

- Size of tree
- Percent live vegetation
- Cones per tree
- Pollen per cone



Locations	Pollen grains/cone
San Marcos	$3.74 \times 10^5 \pm 7.04 \times 10^4$
Junction	$3.63 \times 10^5 \pm 6.32 \times 10^4$
Sonora	$4.72 \times 10^5 \pm 4.23 \times 10^4$
Dallas	$4.02 \times 10^5 \pm 5.91 \times 10^4$

Mean 402,750 pollen grains/cone



Diversity of *J. ashei* locations

Sonora

Balcones



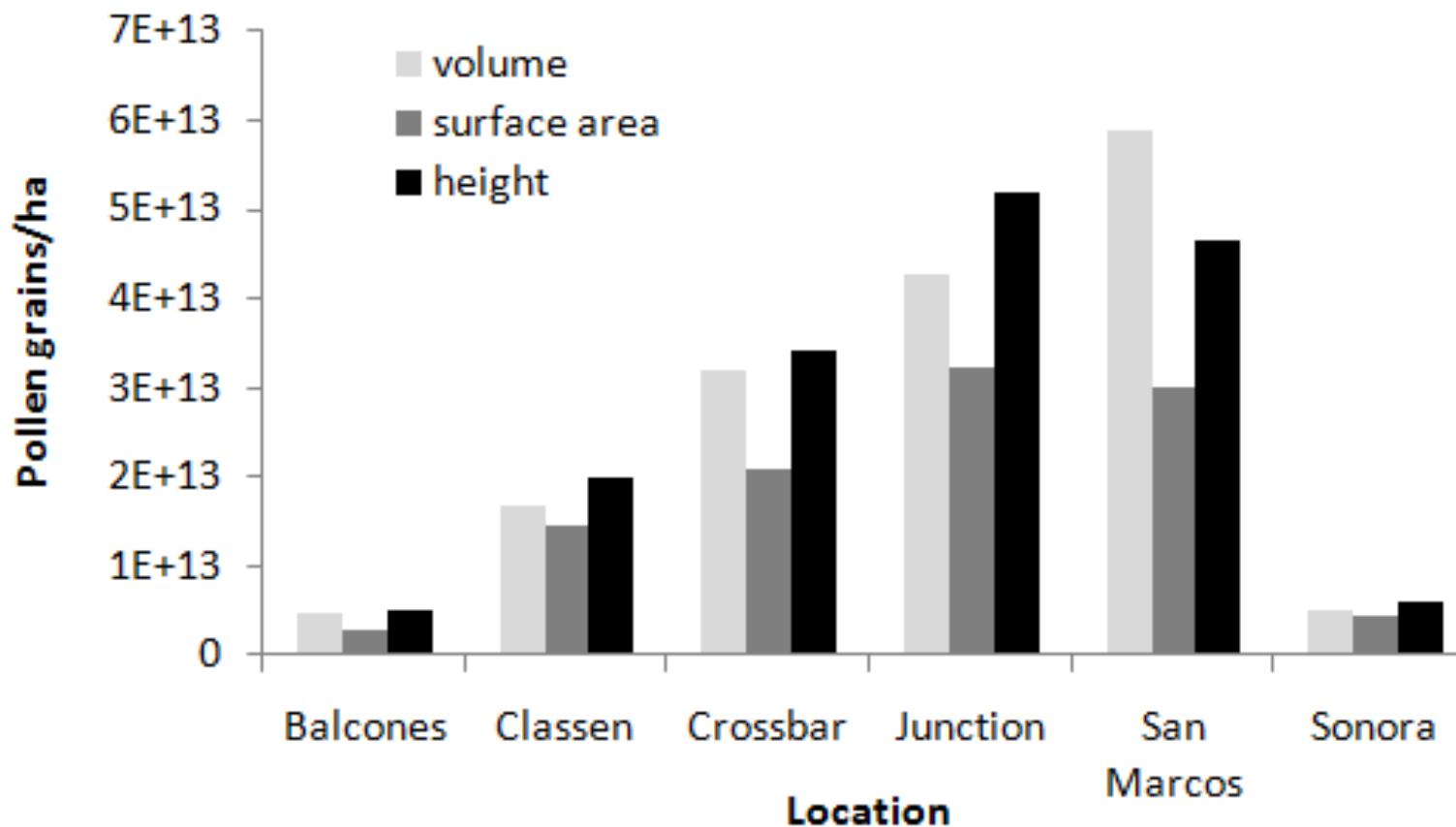


Figure 2.3 Estimated pollen production per hectare using volume, surface area, and height models.

Potential pollen production by our representative trees

Low Cone Producing Trees		High Cone Producing Trees	
Cones	Pollen grains	Cones	Pollen grains
12,952	5.2 billion	93,048	37.2 billion
15,016	6.0 billion	289,288	115.7 billion
34,440	13.8 billion	356,352	142.5 billion
68,416	27.4 billion	509,864	203.9 billion
137,344	54.9 billion	1,375,944	550.4 billion

SUMMARY STATISTICS FOR NEW MEXICO JUNIPER POLLEN

Location	Average daily concentration Pollen grains/ m ³	Peak daily concentration Pollen grains/ m ³	Date of peak	Peak hourly concentration Pollen grains/ m ³	Time of peak hour	Date of peak hour
2010						
Caldera	709	6,578	29-Mar	30,918	10:00 PM	29-Mar
SE Los Alamos	698	9,129	30-Mar	22,855	Noon	30-Mar
NE Los Alamos	501	6,806	30-Mar	12,010	Noon	30-Mar
TijerasA	267	2,655	26-Apr	13,880	Noon	18-Apr
TijerasB	264	3,068	14-Apr	16,560	4:00 AM	14-Apr
Santa Fe	2,196	16,171	30-Mar	52,198	Midnight	30-Mar
2011						
Caldera	417	3,366	11-Mar	9,720	8:00 PM	11-Mar
Mountainair	43	510	21-Mar	2,506	8:00 AM	12-Mar

SEASON LENGTH FOR NEW MEXICO JUNIPER POLLEN

Location	Start Date	End Date	Season Length
2010			
Caldera	17-Mar	19-Apr	34
SE Los Alamos	18-Mar	17-Apr	31
NE Los Alamos	14-Mar	16-Apr	34
TijerasA	13-Mar	5-May	54
TijerasB	7-Mar	28-Apr	53
Santa Fe	18-Mar	15-Apr	29
2011			
Caldera	2-Mar	18-Apr	48
Mountainair	23-Feb	28-Apr	65

Final Tasks

- manuscript on humidity experiments- submitted, *International Journal of Biometeorology*
- Complete the air sampling quality control and summarize all the air sampling data for *Juniperus ashei, J. pinchotii, and J. monosperma*.
- Complete the analysis of the effects of meteorological conditions on airborne pollen levels.
- Prepare manuscripts describing the aerobiology of each species.

Juniper Species and Pollination Season

- ❖ Juniper Ashei (J_a) is mostly found to be distributed over Texas and Oklahoma and pollinates during **December to January**. Thus, the dispersion of juniper pollens during December-January is mostly restricted to J_a type..
- ❖ Juiper Pinchotti (J_p) is mostly distributed over Texas and pollinated during **late September-November**. Thus, the dispersion of juniper pollens during this period is mostly restricted to J_p type.
- ❖ Juniper monosperma (J_m) and Juniper scopulorum (J_s) are prevalent in New Mexico and pollinates during **March-May** period. Thus, the dispersion of juniper pollens during this period is mostly restricted to J_m and J_s type.

Pollen release potential Source Map/Mask

(PRPSM_of_J_i) of a Juniper species “*i*” is calculated as:

$$\text{PRPSM_of_J}_i = T_i \times M_i \times H_i \times C_i \times P_i$$

Where

T_i = Number of J_i trees

M_i = Male/Female ratio of J_i

H_i = HCP_LCP/All ratio for J_i

C_i = Cones per J_i tree

P_i = Pollen grains per cone for J_i

The number of trees of a Juniper species “*i*” per grid cell is calculated as

$$T_i = \text{GAP}_i \times \text{MODIS} \times \text{TC}$$

Where

GAP_i = Fraction of J_i at 1 km grid (range 0-1)

MODIS = MODIS derived percent tree cover per 1 km² grid cell (in fraction, range 0-1)

TC = Tree count or number of trees.

Ground truth (transect data)

(a) Male to Female ratio

(b) HCP_LCP to All ratio

- ❖ 0 – Only enough cones to determine gender
- ❖ 1 – Low Cone Production (LCP) tree
- ❖ 2 – High Cone Production (HCP) tree

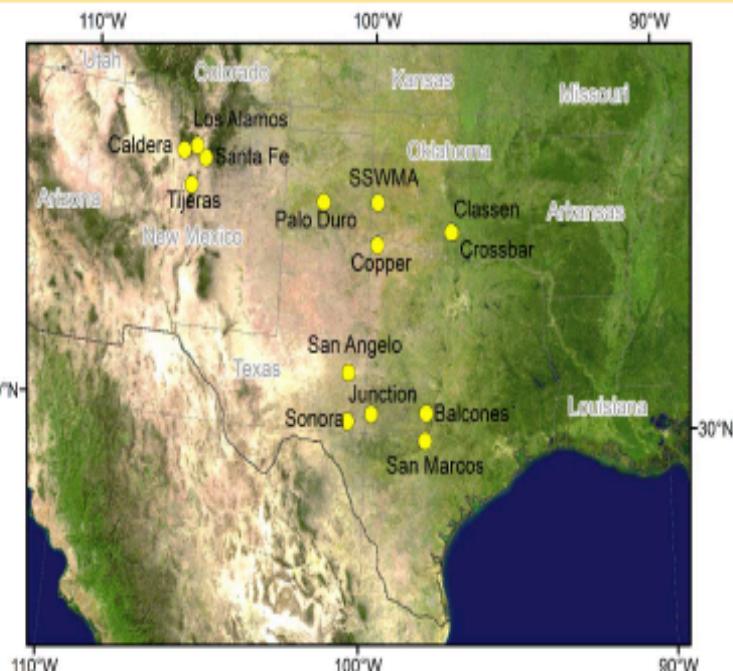
(c) Cones per tree

(d) Pollen grains per cone

(d) Age

(Height & edge effect)

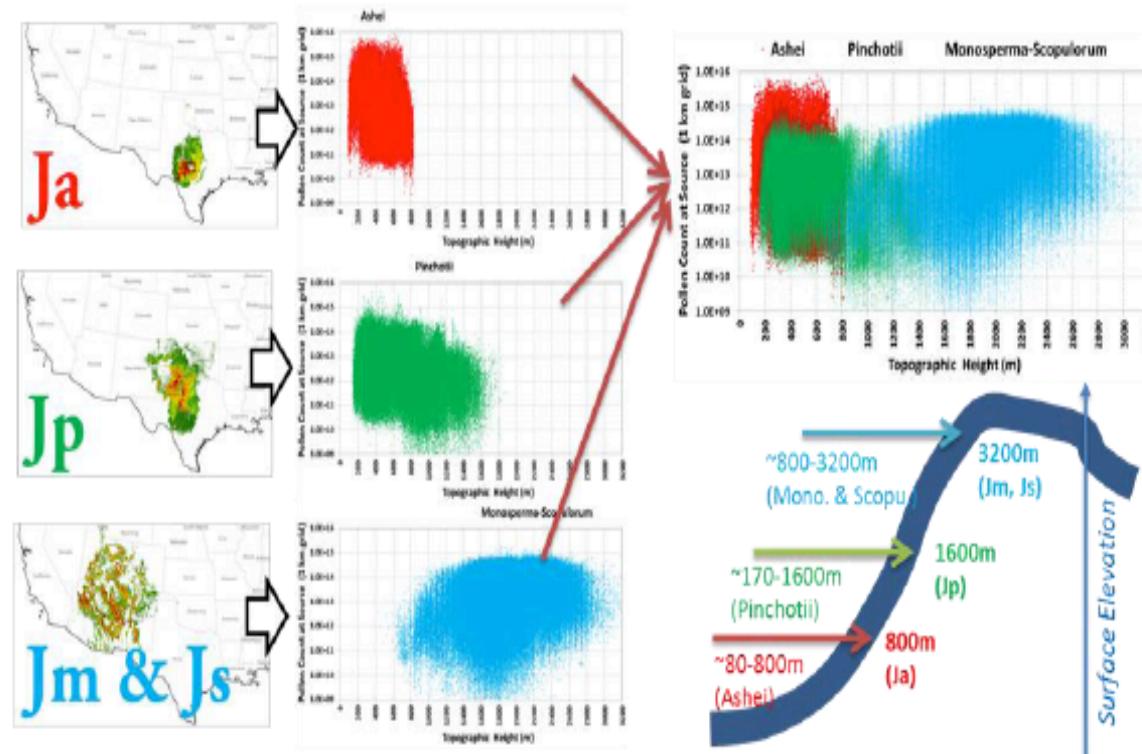
JPP Sampling sites



Pollen related data have been collected at the following air sampling locations:

- Balcones
- Sonora
- Palo Duro
- Classen
- Tijeras
- SSWMA
- Crossbar
- Santa Fe
- Copper
- Junction
- Los Alamos
- San Angelo
- San Marcos
- Caldera
- Sonora

Topography and Juniper Species



Relationship between the topography and spatial distribution of Juniper species.

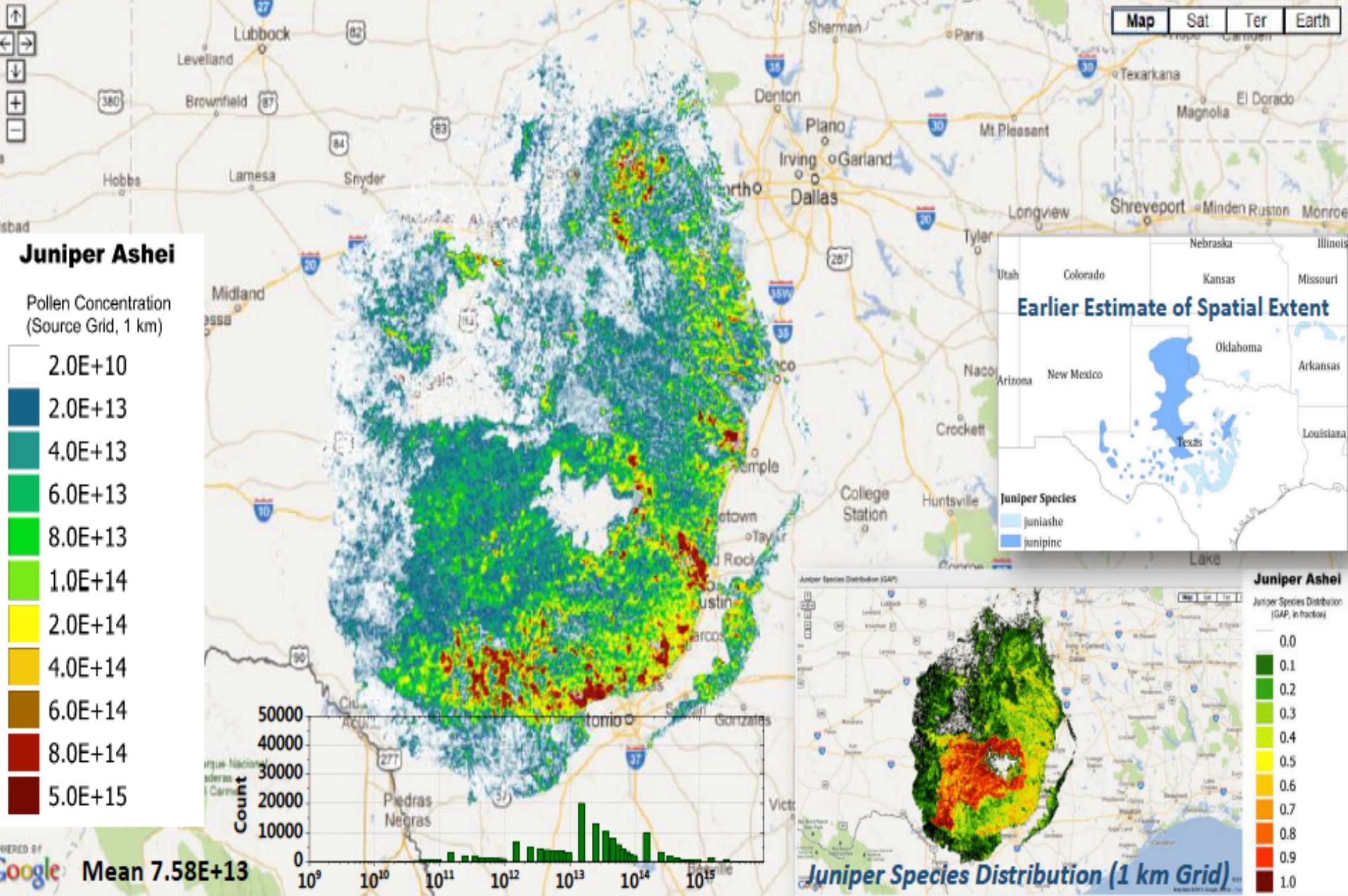
- *Juniperus ashei* (*Ja*) is generally found in lower elevations (80-800m),
- *Juniperus pinchotii* (*Jp*) in medium elevations (170-1600 m) whereas
- *Juniperus monosperma* and *Juniperus scopulorum* (*Jm* and *Js*) are generally dominant in higher elevations (800-3200 m).

Juniper Ashei

mean = 7.58E+13

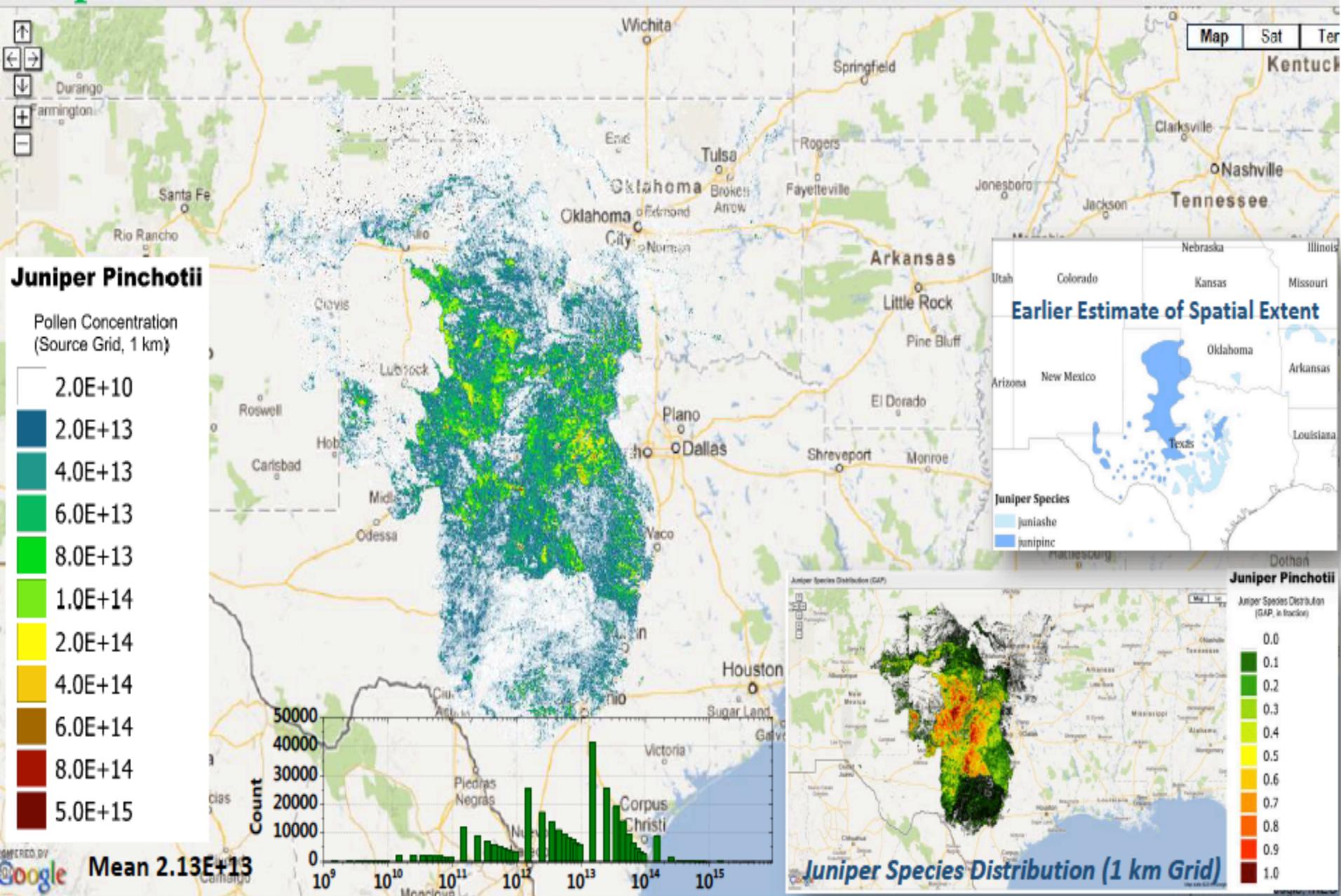
Pollen Concentration (Source Grid, 1 km)

Map Sat Ter Earth



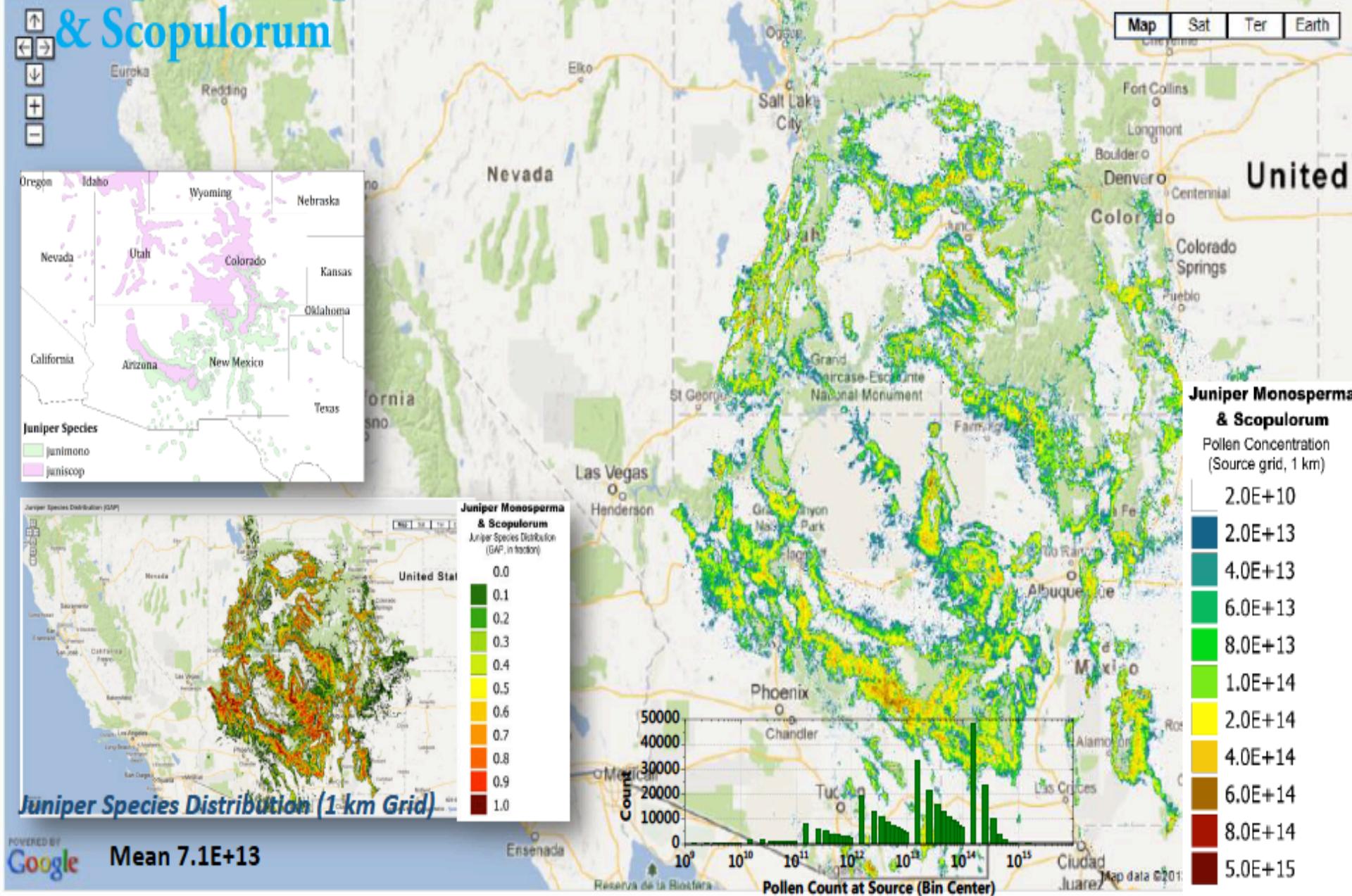
Juniper Pinchotii

Pollen Concentration (Source Grid, 1 km)



Juniper Monosperma & Scopulorum

Pollen Concentration (Source Grid, 1 km)



PREAM Quasi-operations (QO)

- ❖ QO running at the UA
- ❖ Model resolution: 1/3 deg (~37 km²)
- ❖ Daily forecasts
- ❖ Products available on the UA ftp server:
 - ❖ Maps for surface concentration (#/m³), every 3 hours, 0-48h forecasts
 - ❖ gridded values in ascii form; in #/m³
 - ❖ time-concentration graphs for the 0-48h forecast period for observation sites

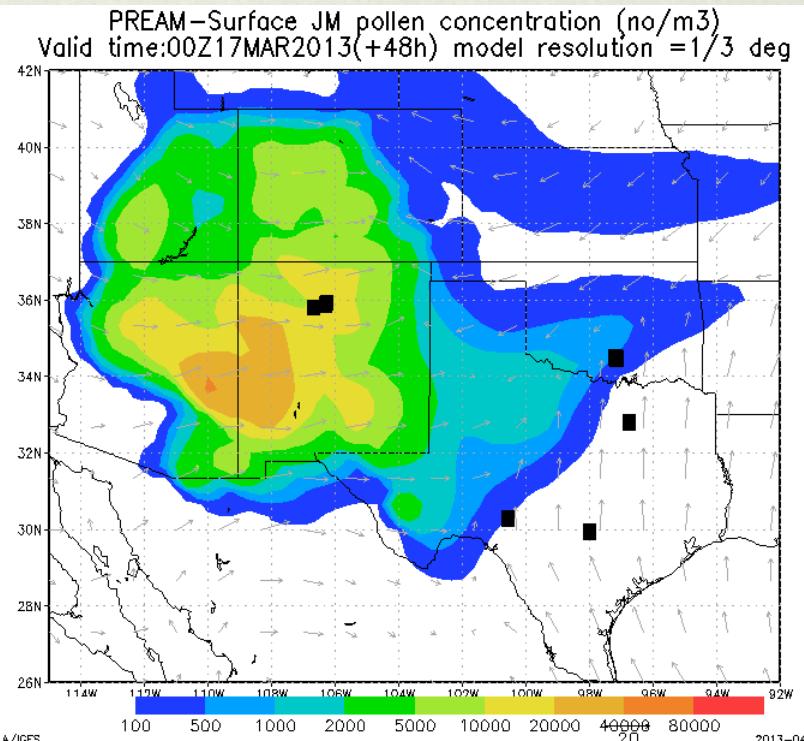
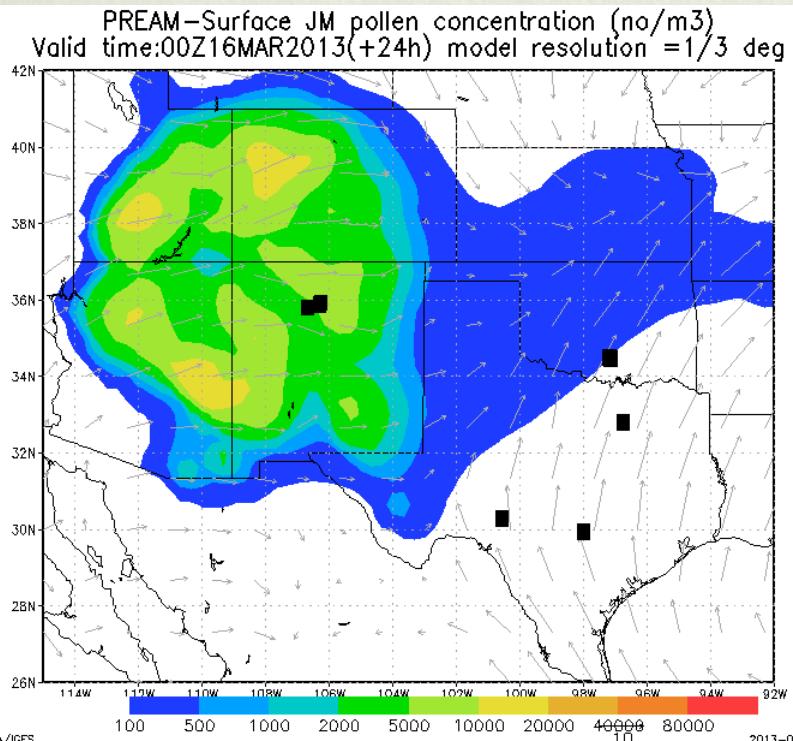
Quasi-operations

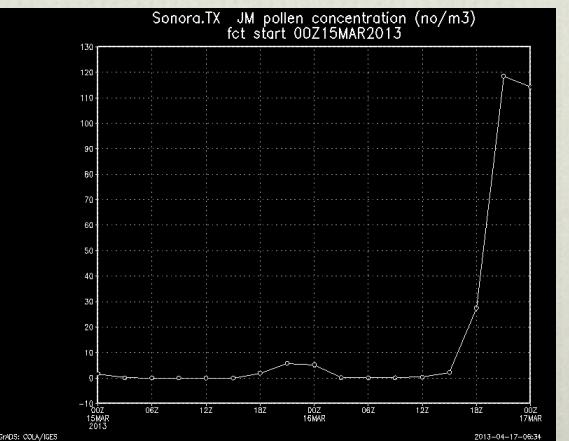
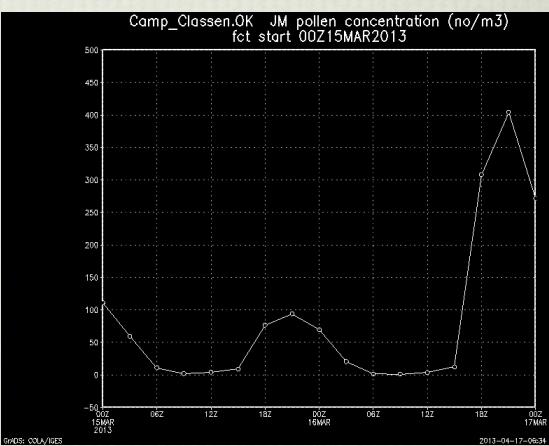
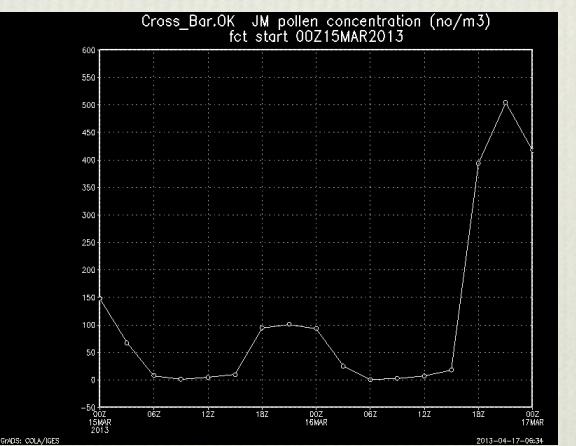
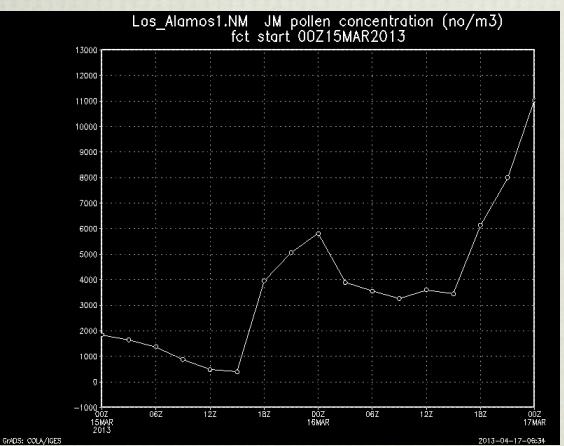
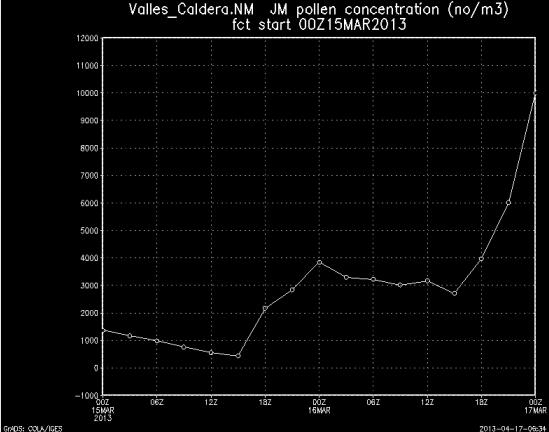
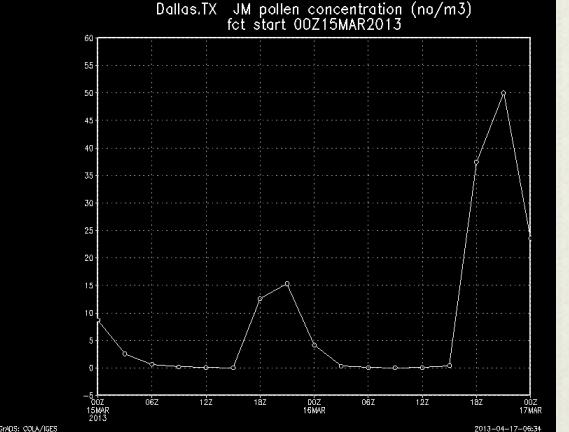
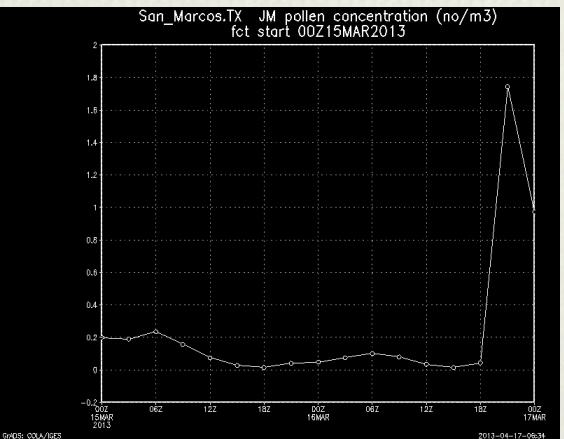
Periods of operations

- ❖ *J. ashei*
 - ❖ 15 Dec 2012 – 28 Feb 2013
- ❖ *J. monosperma*
 - ❖ 1 Mar – 6 May 2013
- ❖ *J. pinchotii*
 - ❖ 1 Oct - Nov 2013 - ongoing

J. monosperma
1 Mar – 6 May 2013

PREAM J. monosperma Plume Forecast: (L) 24-hr and (R) 48-hr





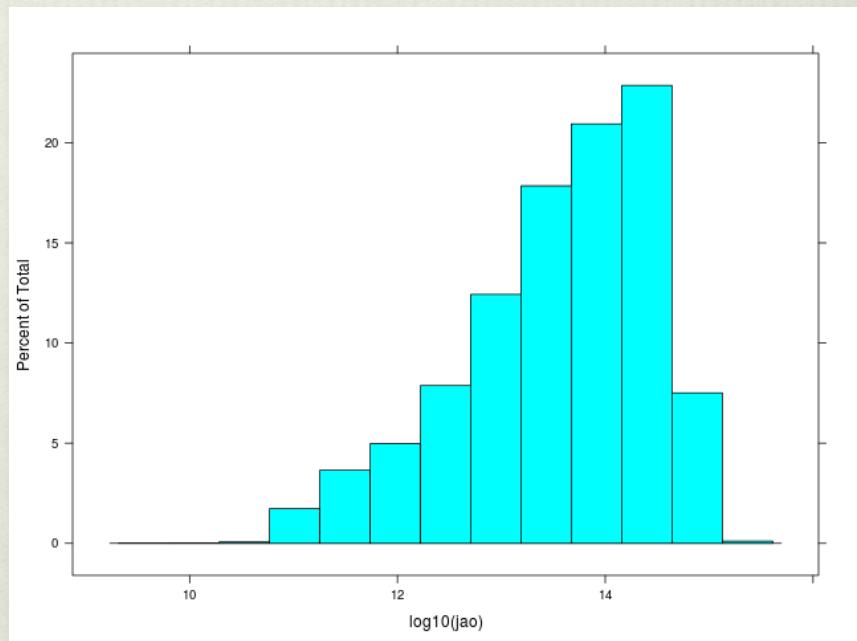
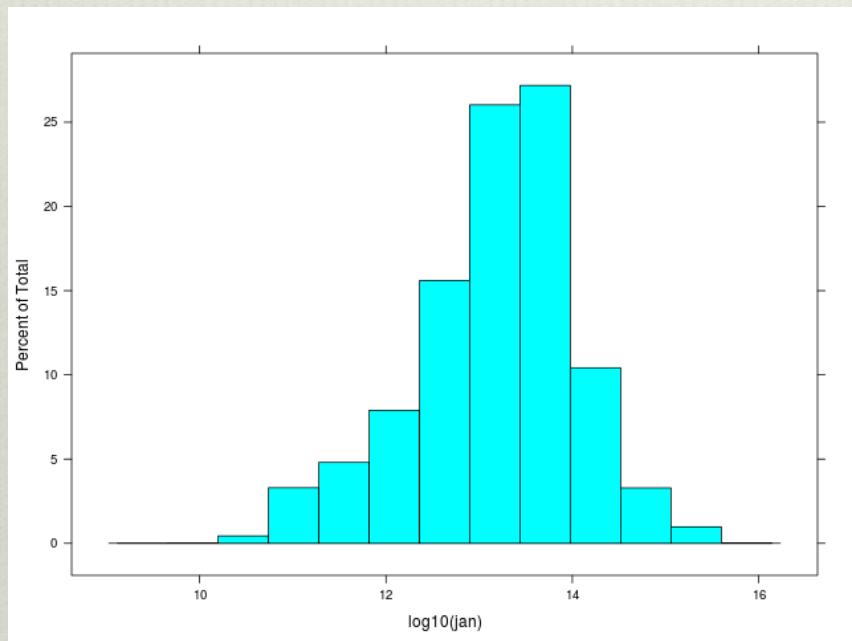
Hindcast runs

- ❖ New Anup's masks
- ❖ Doubled resolution of 1/6 deg ($\sim 18.5 \text{ km}^2$)
- ❖ Compared new/old mask runs for selected periods

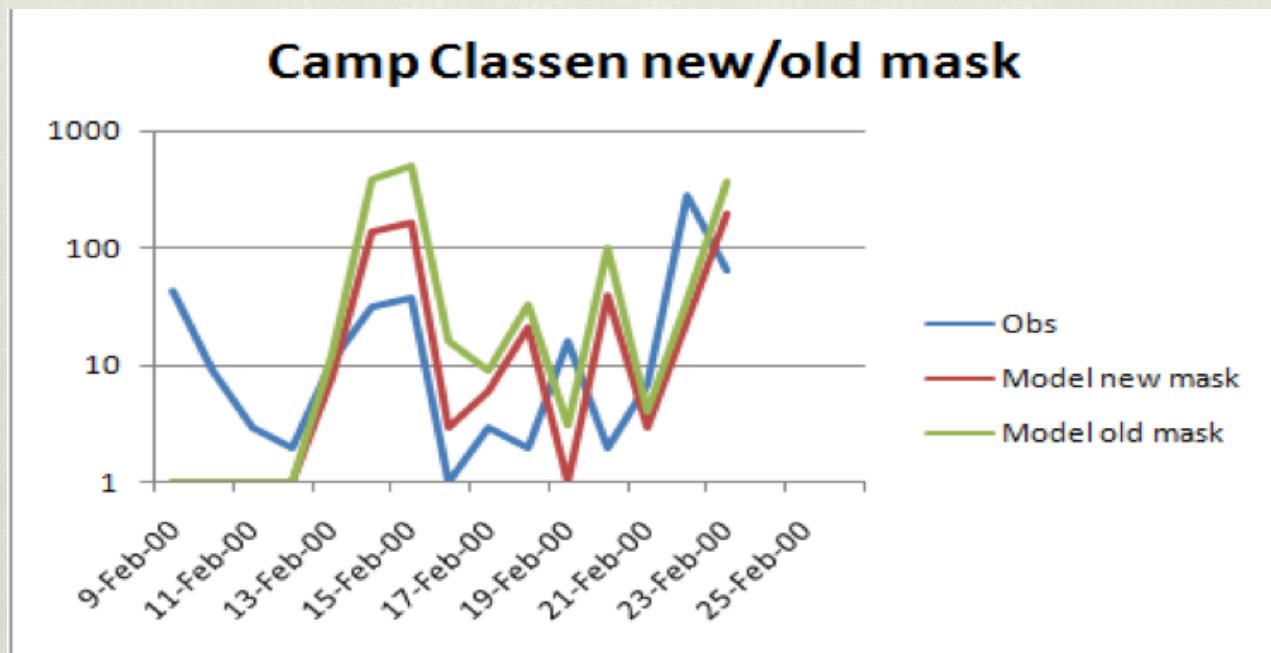
Hindcast runs

- ❖ Hindcast periods
 - ❖ *J. ashei*
 - ❖ 2009/10 season
 - ❖ 2010/11 season

Values frequency distribution in the new (L) and old (R) *J. ashei* masks



PREAM vs. Observed, *J. ashei*
2010-11 Season
1/6 deg. Horizontal Resolution
New model old/new mask



Article

Response of Spectral Reflectances and Vegetation Indices on Varying Juniper Cone Densities

Dailiang Peng ^{1,*}, Zhangyan Jiang ², Alfredo R. Huete ³, Guillermo E. Ponce-Campos ^{4,5},
Uyen Nguyen ² and Jeffrey C. Luvall ⁶

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³ Plant Functional Biology and Climate Change Cluster (C3), University of Technology, Sydney, NSW 2007, Australia; E-Mail: alfredo.huete@uts.edu.au

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E-Mail: geponce@gmail.com

⁵ Soil, Water and Environmental Sciences, University of Arizona, Tucson, AZ 85721, USA

⁶ Marshall Space Flight Center, NASA, Huntsville, AL 35805, USA; E-Mail: jlувall@nasa.gov

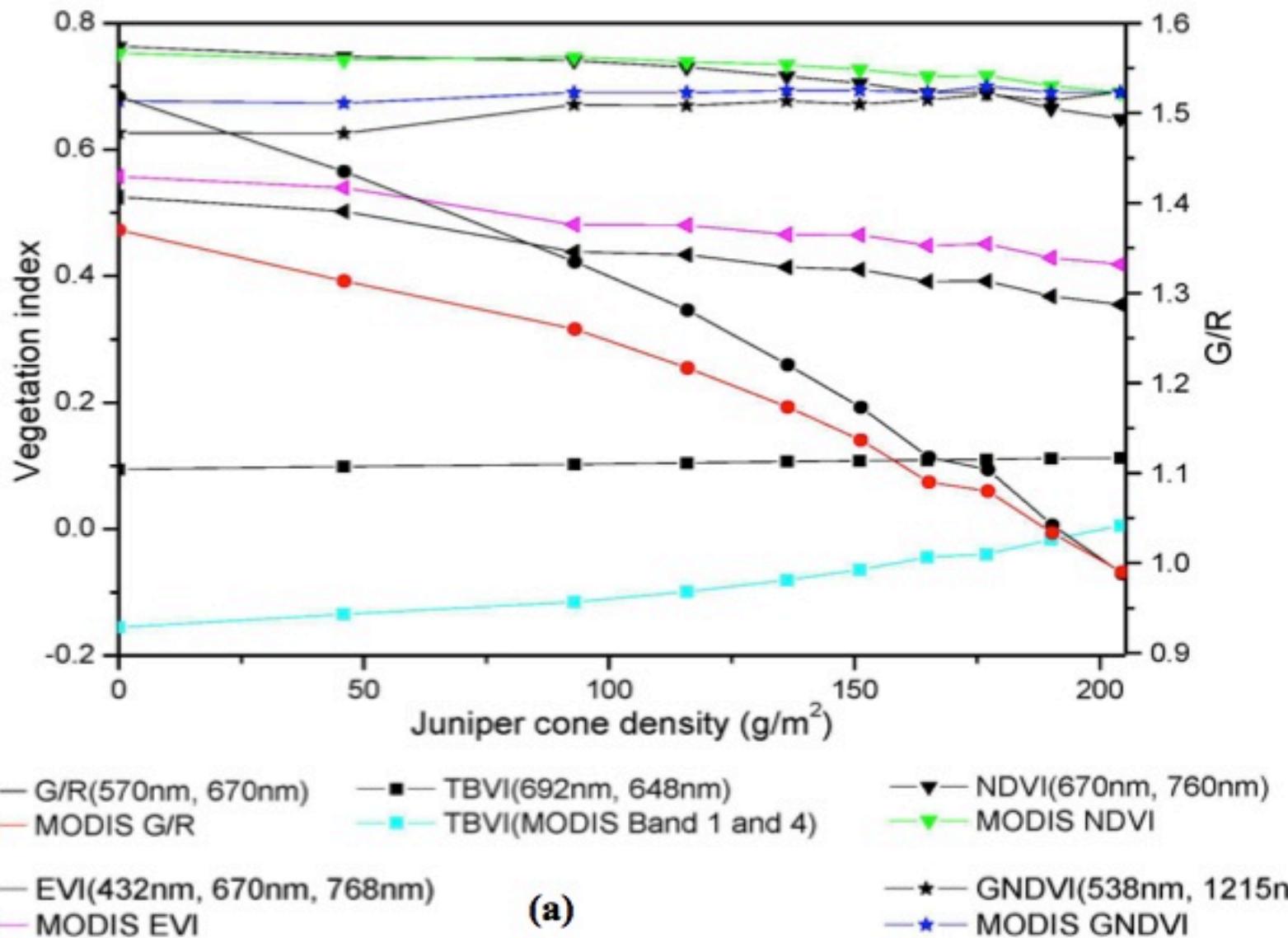
* Author to whom correspondence should be addressed; E-Mail: dlpeng@ceode.ac.cn;
Tel.: +86-10-8217-8181; Fax: +86-10-8217-8177.

Received: 24 August 2013; in revised form: 29 September 2013 / Accepted: 8 October 2013 /

Published: 22 October 2013

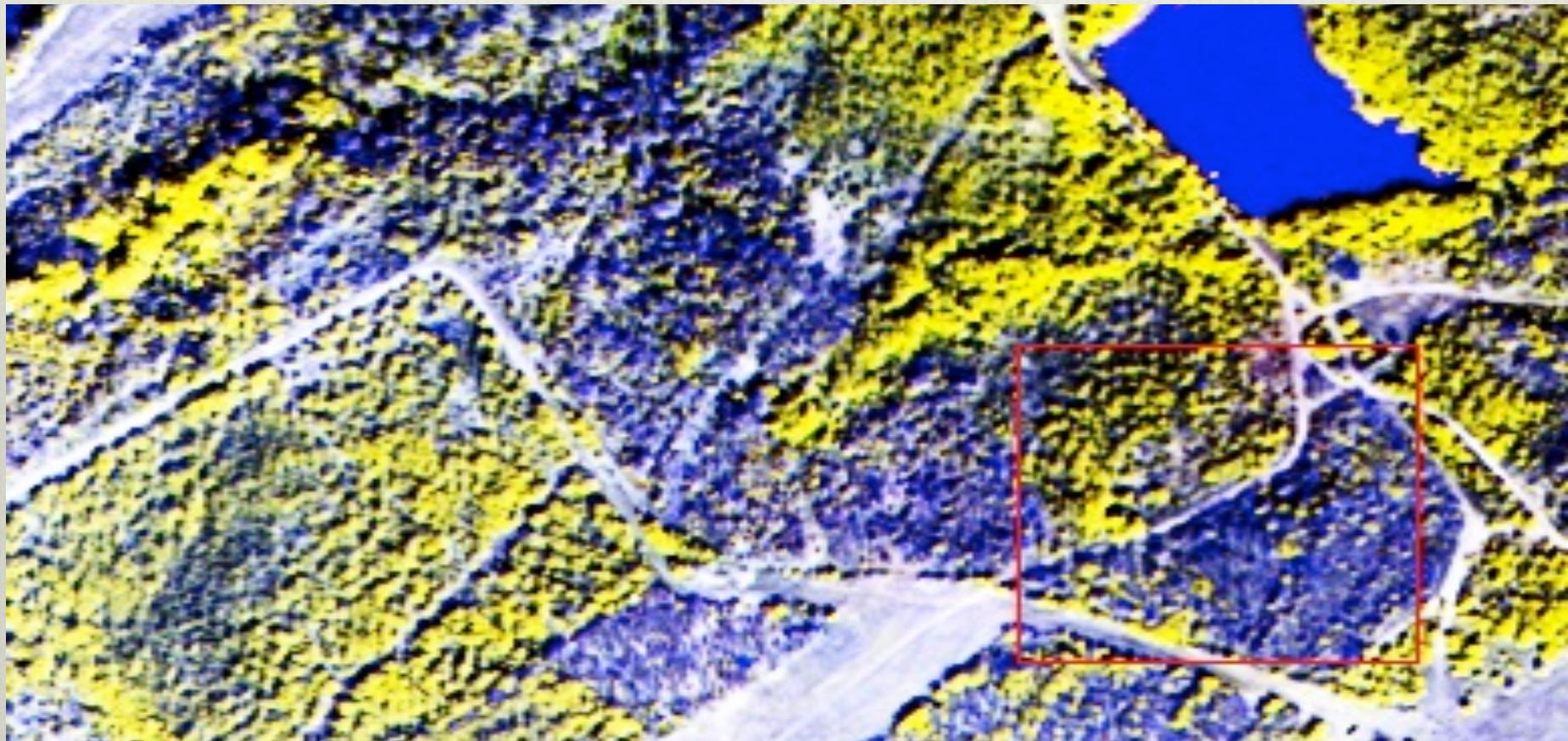


Figure 6. (a)Vegetation index and (b) relative changes of vegetation index (including G/R) at different juniper cone densities, those vegetation indices calculated by MODIS Bands and narrow bands with the best-fit R² values in Table 2



WV2 jan 6 2011

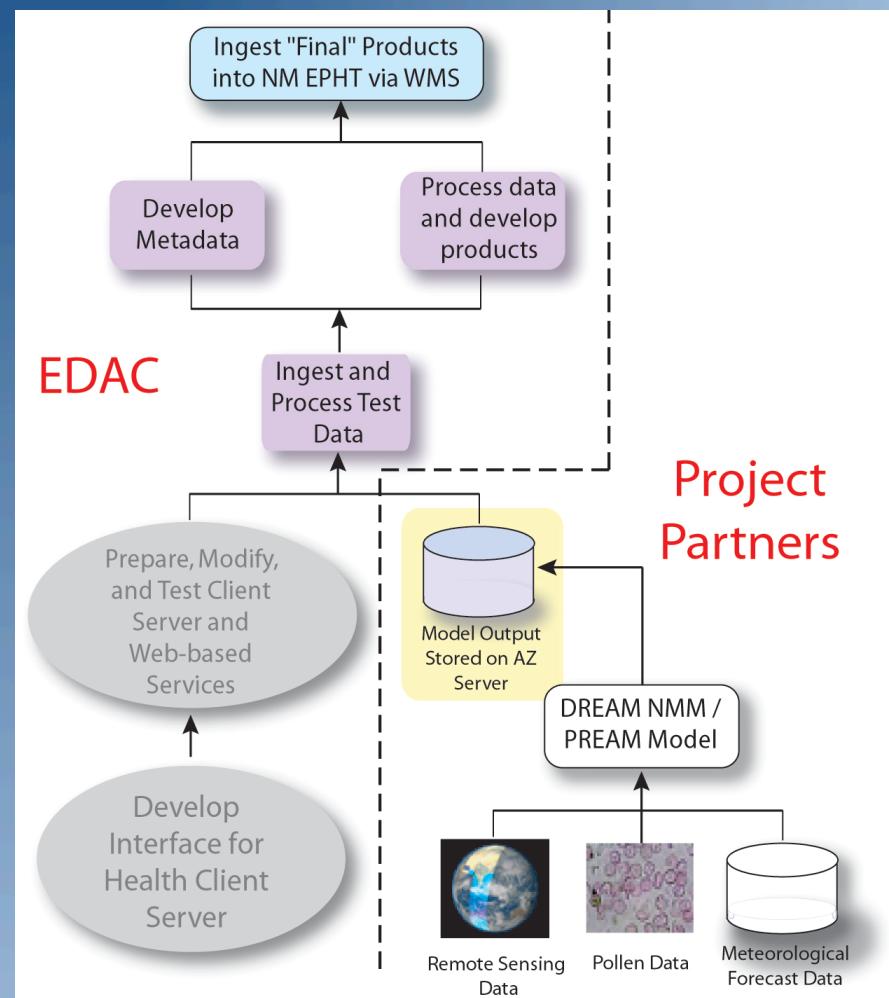
r=7(765-901) g=8(856-10430 b=442-515)



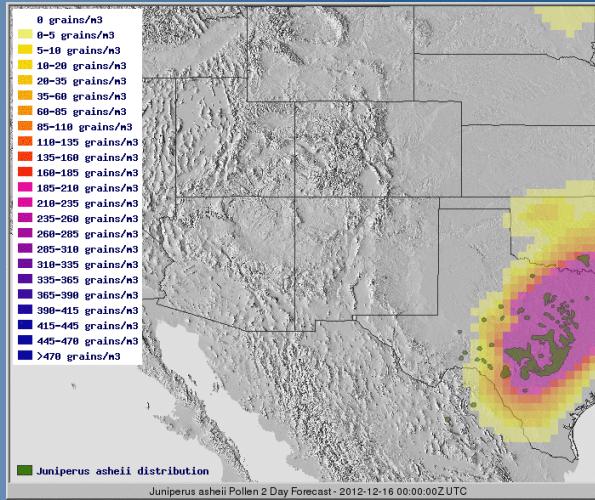
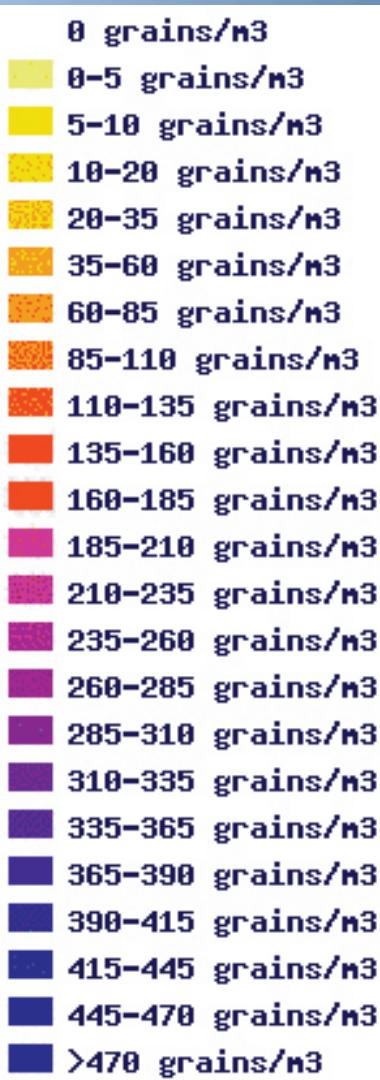
WVSP #2 (3473,0300) current R:02 G:00 B:202
Projection: Geographic Lat/Lon
LL: 29°13'40.64"N, 98°8'53.30"W
Data: R:256 G:268 B:247

Progress (Sept 2012 – Sept 2013)

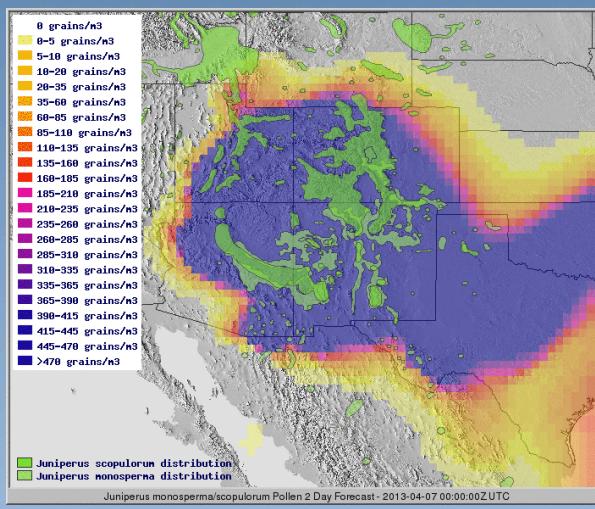
- Recent progress and completion of tasks are represented in the purple boxes
- Grey ovals indicate completion of tasks in previous project years (for dust forecasts)
- Blue box represents what needs to be finished by end of the project
- Project partner activities are illustrated right of the dash line



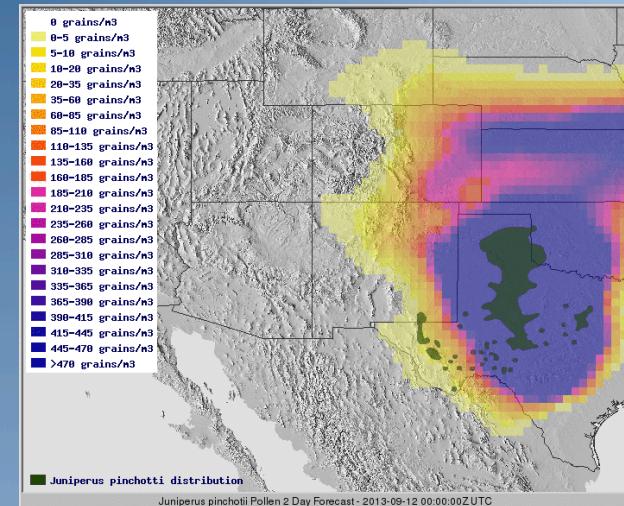
Sample Animation Products



2-day forecast of
J. ashei pollen at
3-hr intervals for
Dec 16-17, 2012



2-day forecast of
J. monosperma /
J. scopulorum
pollen at 3-hr
intervals for
Apr
7-8, 2013



2-day forecast of
J. pinchotii
pollen at 3-hr
intervals for Sep
12-13, 2013

Timeline & Expected Accomplishments

Task	Target Date	Status
Develop post-processing scripts to build archive	9-1-12	Completed
Post-process model output data	11-1-12	Completed
Ready to accept data stream	11-1-12	Completed
Collaborate with NPN & NMDOH on V&V tests		In progress
Develop metadata		In progress
Determine final deliverables/products		Dependent on V&V
Presentations at professional conferences		As needed
Contribute material for publications		As needed
Prepare annual reports	Annually	Done
Prepare final report	3-31-14	



Clinical Findings: Chronic Lung Disease Exacerbation

Symptoms (Reported by Patient)



Productive Cough? Yes No Nasal Discharge? Yes No

Sore Throat? Yes No Wheezing? Yes No

Underlying Lung Disease (Asthma/COPD)? Yes No

Clinical Signs (from Physical Examination)



Temp(C) < 37.0 37.0 – 37.9 38.0 – 38.9 39.0 – 39.9

Predominant Lung Findings Rales Wheezing Bilateral Unilateral

Skin Rash? Yes No Oral Lesions? Yes No

Lymphadenopathy? Yes No Diffuse Localized

Splenomegaly? Yes No Hepatomegaly? Yes No

Laboratory and X-Ray Data



WBC Count: < 5,000 5,000 – 10,000 10,001 – 15,000 > 15,000

Platelet Ct. < 50,000 50,000 – 100,000 100,001 – 150,000 > 150,000

Chest X-Ray: Normal Abnormal

Infiltrate Hyperinflation Cardiomegaly Effusion

O2 Sat. (Room Air) Normal Abnormal



Juniper Pollen Project



Project Overview

- Model juniper pollen spread in near real-time, inform public health
- **USA-NPN's role:** engage *Nature's Notebook* participants in tracking juniper phenology





Juniper Pollen Project

What USA-NPN provided:

- Observation protocols
- Data management, archive, visualization, and access
- Mechanisms to engage potential observers
 - Project advertised on USA-NPN website
 - Invitations and updates via newsletter



Juniper Pollen Project

Project outcomes

- 56 observation sites in 5 states
- >10,500 records of juniper pollen phenology (2010-2013)
- Team members are using observations to validate satellite data





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Supported by:
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Additional funding by:



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Foundation

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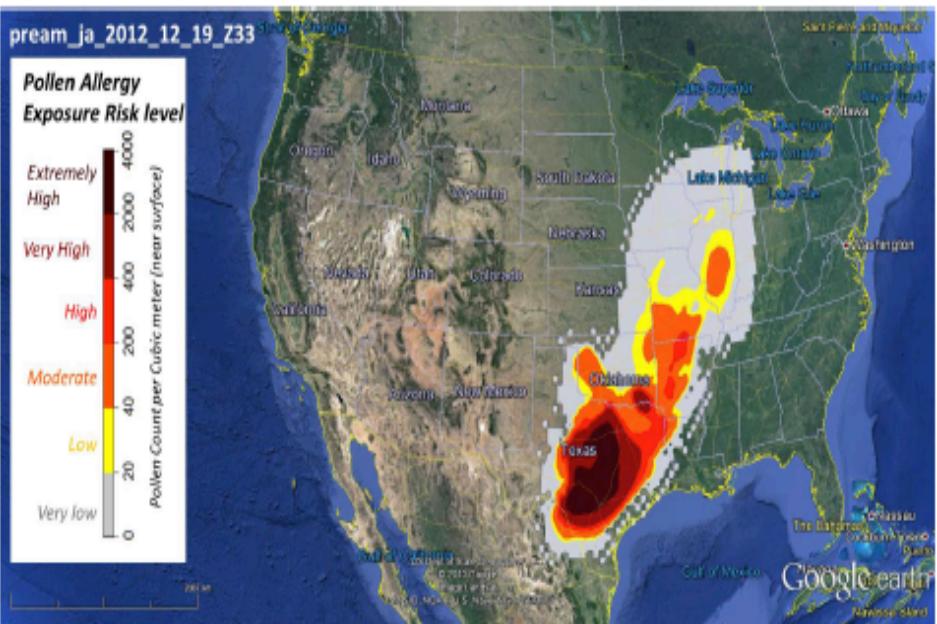
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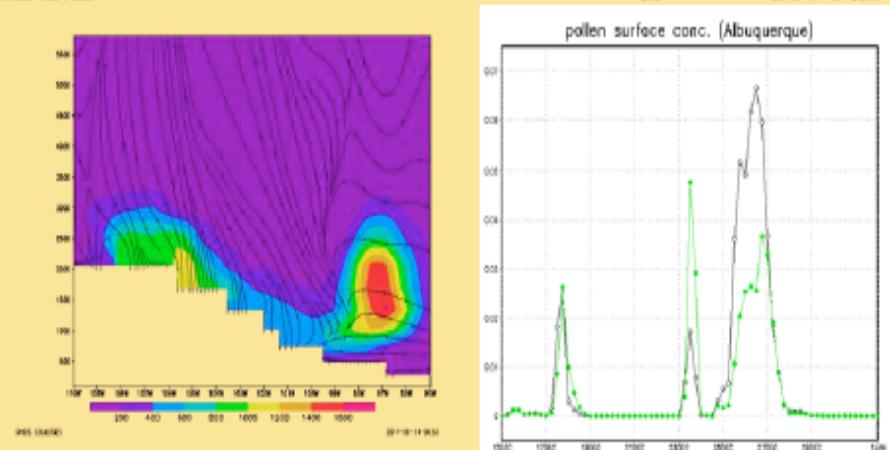
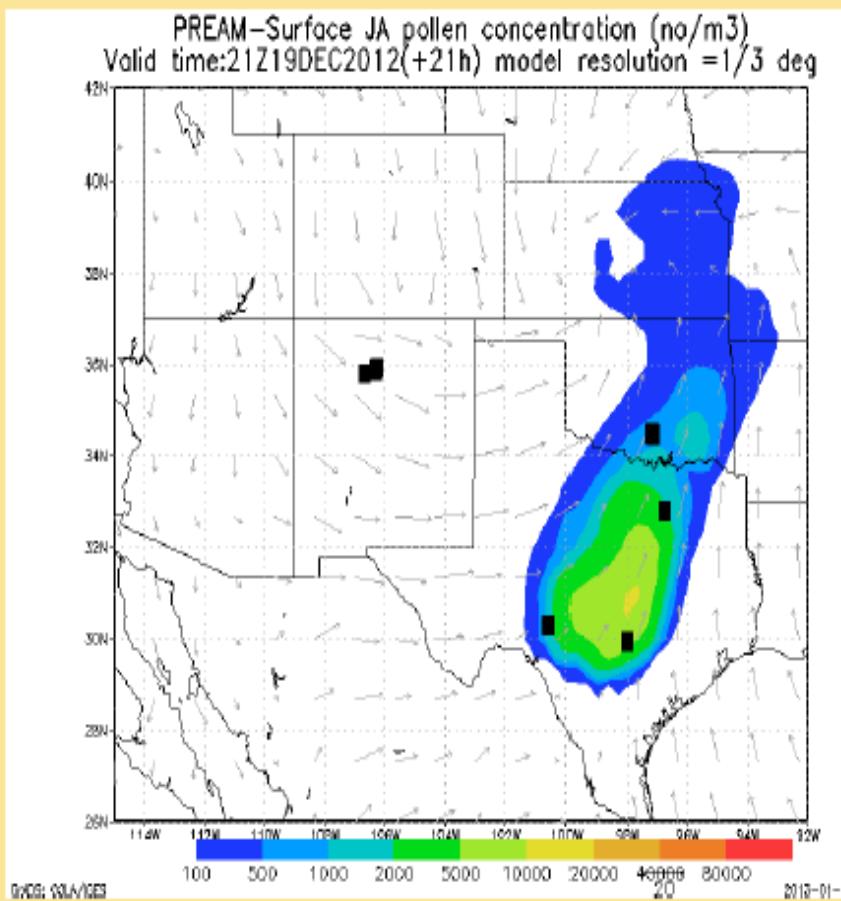
<http://pbskids.org/scigirls/>

NSF Funded – Estelle possible November production

PREAM simulated forecast of juniper pollen (*Juniperus ashei*) associated allergy risk during winter season



Allergy Risk Index



■ Publications & Presentations

Publications:

Response of Spectral Reflectances and Vegetation Indices on Varying Juniper Cone Densities.

Dailiang Peng, Zhangyan Jiang, Alfredo R. Huete, Guillermo E. Ponce-Campos, Uyen Nguyen and Jeffrey C. Luval.

Remote Sensing *Remote Sens.* 2013, 5, 5330-5345

Predicting and Quantifying Pollen Production in *Juniperus ashei* Forests. 2012. Bunderson, L., P. Van De Water, H. Wells, E. Levetins. *Phytologia* 94 (3): 417-438.

Presented:

“Juniper Pollen Hotspots in the Southwest” - 2013 AAAAI annual meeting

An invited seminar entitled “Pollen Forecasting and Exposure: A View from Space” presented at the 2013 AAAAI annual meeting.

American Thoracic Society 2013

Ecological Society of America 2013

AGU 2012 & AMS 2013

Dissertation:

Landon Bunderson, 2013. Aerobiology And Pollination Ecology of *Juniperus Ashei*

WebNews:

NASA Meets Public Health on the Juniper Pollen Project By [Norene Griffin](#) [September 25th, 2013](#)

- <http://scistarter.com/blog/2013/09/nasa-meets-public-health-juniper-pollen-project/#sthash.KttsN24H.dpuf>



Redefining Final Deliverables?

Task	Target Date	Status
Develop “quasi-operational” value-added products of pollen forecasts	5-1-13	In progress
Include prototype pollen data/visualizations on NM IPHT dashboard		TBD
Develop (modify) & test web-based client server	1-1-13	TBD
Install client server & model interface on EPHT	3-1-13	TBD
Maintain quasi-operational client server	TBD	TBD
Introduce, initiate & test prototype server access for NM, OK, & TX public health services	TBD	TBD
Evaluate results & complete system transition	TBD	TBD
Assess continued use of system by NM, OK, TX	TBD	TBD
Formulate recommendations for improvement	TBD	TBD



Final 8 months

Pollen Sampling Activities

Sampling completed
Pollen release timing concentrations & microclimate

Remotely Sensed Data

MODIS pollen source masks for all Juniper communities

DREAM Modeling

MODIS generated pollen source masks
Output products into EPHTN/SYRIS
Ongoing validation

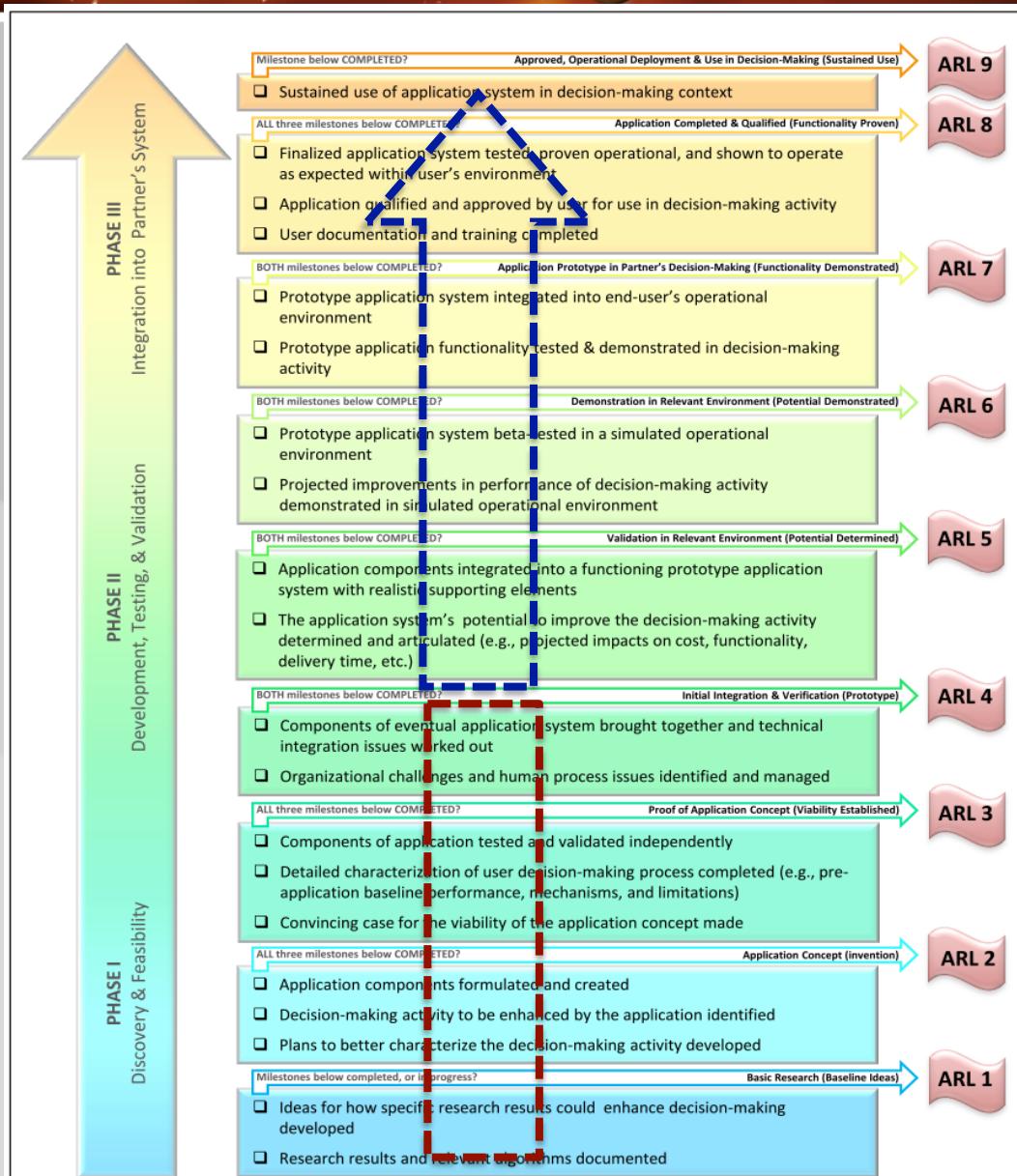
Public Health Support

SYRIS- absenteeism & PREAM (~15K, 2yrs)
SYRIS to accept PREAM output via EDAC
Data products for EPHTN
Quasi-operational system
Integration into decision support systems**

**Uncertain depending on partner's funding



Application Readiness Level Status



	PY13				
Institution	Budget	Obligated	Unobligated	Costed	Uncosted
MSFC	27,367	26,599	768	24,615	0
Univ of AZ	122,952	122,952	-	58,322	0
Univ of NM	60,437	60,437	-	3,017	57,420
CA State	11,258	11,258	-	-	0
Univ of Tulsa	9,445	9,445	-	32	0

